COARSE-GRAINING AND CRITICAL SPIN CORRELATIONS IN PYROCHLORE ANTIFERROMAGNETS

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Abstract

Consider the Ising spin antiferromagnet on the pyrochlore lattice consisting of corner-sharing tetrahedra. (Isotropic 3-component spins are a minor extension.) The ground states are highly degenerate and map to configurations of arrows on the edges of a diamond lattice; the ground-state constraint that every tetrahedron has zero net spin translates to the "ice rule" (two arrows in and two out of every diamond-lattice vertex), as is well known. Consequently, the vector field of coarse-grained arrows $\mathbf{E}(\mathbf{r})$ has zero divergence; furthermore, the free energy (from entropy) has the form $\int d^3\mathbf{r}|\mathbf{E}(\mathbf{r})|^2$. Thus the arrow field behaves as a pseudo "electric field" without sources. This has the following consequences:

(a) The spin correlations have the form of a dipole-dipole interaction, thus they are *critical* (decay with distance as a power-law). This is already known in the ice context [1, 2].

(b) The diffuse magnetic scattering has a very low intensity over the entire first Brillouin zone; it is virtually zero along the (100) axes, and exhibits pinch-point (pseudo-dipolar) singularities at (200) and (111) points. All this is observed in pyrochlore systems experimentally[3] and in simulations[4]. An extension of this approach produces a phenomenological fitting formula for diffuse intensity thoughout the Brillouin zone, similar in form to Ref.[5].

(c) The AC susceptibility behavior[6] should be cast in terms of the diffusion and recombination of pseudo "electric charges".

References

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